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Developing a resilience framework to analyze farmer perspectives on threat and vulnerability to catastrophic events in Western Washington State

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Developing a Resilience Framework to Analyze Farmer Perspectives on Threat and Vulnerability to Catastrophic Events in Western Washington State

By

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MASTER'S THESIS

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Bryant Hammond
April 19, 2011

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A Thesis
Presented to
The Faculty of
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Abstract

Agriculture plays an important role in Western Washington's culture, economy, and environment. However, agriculture as it has been practiced over its 150-year history in the region is currently threatened by several changes differing in severity and onset speed. This thesis examines the adaptation of farmers to the changing system in which they are situated by exploring how they view vulnerability and threat; what strategies they suggest might aid in adaptation; and how farmers situate themselves and their operations within larger socio-ecological systems. I derive my data from disaster planning workshops in which farmers from each of three counties participated in facilitated discussion identifying threats, potential thresholds to irreversible change, and suggested adaptive strategies to counter perceived threats. I find that although the skill set required to successfully farm theoretically involves a great deal of resilience and adaptability, farmers' notions of resilience and adaptation hinge on stability and predictability, characteristics theoretically differing from resilience. Further research on the apparent conflict between desired stability and the development of resilience in agricultural systems might help in understanding the origin and nature of the apparent conflict ands steps that may resolve it.

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List of Abbreviations

Common Agricultural Policy……CAP

Department of Ecology……DOE

Department of Natural Resources and Parks……DNR

Environmental Protection Agency……EPA

Federal Emergency Management Agency……FEMA

United States Department of Agriculture……USDA

United Nations International Strategy for Disaster Reduction……UNISDR

Washington State Department of Agriculture……WSDA

Chapter 1: Introduction

Agriculture has played a prominent role in the development of Western Washington State rural geographies following European settlement in the region. The region's combination of temperate climate, moderate rainfall, and productive soils create favorable conditions for the production of a range of agricultural crops (Klein & Reganold, 1997). With such resources, residents inhabiting the region have put much of the land towards agricultural uses over the past 150 years.

Western Washington, indeed American agriculture as a whole, has changed significantly over the past 60 years (Hart, 2003; Roberts, 2008). The sector continues to change in terms of structure, size of operation, and production methods in response to social, economic, and environmental pressures. Such pressures present both opportunities and threats (Ikerd, 2001) to the individual operation and agricultural region. Opportunities, such as expanding direct markets and new production technologies, and threats, such as urban encroachment, rising costs of production, and public concern of production methods, will produce "winners" and "losers" in both existing and startup operations (Table 1). Some individual farms will certainly prosper, while others will fail. Indeed, the agricultural landscape of the United States will continue to shift as it has since World War II (Hart, 2003), with the sector growing and thriving in some regions, while moving out of regions of historical agricultural production.

In such a dynamic and constant evolving environment, how do farmers respond to threats, take advantage of opportunities, and successfully adapt their operations to changing conditions? The purpose of this study is to explore the nature of farmer

vulnerability and adaptation to such conditions. I do so by developing an explanatory framework through an analysis of Western Washington farmer perspectives on vulnerability and resilience in relation to their operations, community, and the larger agricultural sector within the context of four plausible disaster scenarios.

Threats	Opportunities
Flooding (Green, Miles, Gulascik, & Levy, 2008)	Increasing technological sophistication (Hart, 2003; Roberts, 2008)
Drought (Fontaine, 2007; Keil, Zeller, Wida, Sanim, & Birner, 2008; Miller, et al., 2009; Ranjan & Athalye, 2008; Zarafshani, Gorgievski, & Zamani, 2007)	Expanding niche markets (Cho & Tobias, 2010)
Climate Change (Kruger, 2008)	Climate change (Drake, Gonzàlez-Meler, & Long, 1996; Stöckle, et al., 2009)
Severe storms (Thurston County Emergency Management, 2004)	Greater interest in agriculture
Rising costs of production (Berardi, 2009)	Expanding markets through globalization
Urban Encroachment (Klein & Reganold, 1997)	Opportunities to consolidate and grow (Hart, 2003)

Table 1: Examples of threat and opportunity in United States agriculture.

Despite favorable growing conditions, farmers in Western Washington State face several threats to current and future viability within the sector, such as frequent flooding, loss of adequate farmland, and atrophy of farming services and infrastructure. Expected threats can occur quickly with little to no warning, such as flooding or sudden increases in input costs, or can occur slowly over longer time periods. Some threats, such as climate change and urban encroachment, are not as obvious due to slow onset and their existence is cause for debate. Yet, if the region's agriculture will survive it will

have to weather changes over the long term; indeed, for the region's agriculture to thrive, it will have to adapt to changes in structure, scale, and method of production in the sector and larger landscape and climatic changes so as to take advantage of the opportunities such threats might offer.

This thesis seeks to shed light on the problem of farm adaptation to the evolving and unique challenges the changing sector, society, and climate pose by starting with the following three research questions:

1. What makes farmers in Western Washington State vulnerable to urbanization, climate change, rapid increases in energy costs, and flooding?
2. How do farmers approach vulnerability and adapt to such different and evolving threats?
3. How do farmers understand their position within larger scales of the socio-ecological system in which they are situated?

To answer these questions I draw on data derived from farmer discussions and perspectives, expressed in disaster-planning workshops, in San Juan, Snohomish, and Whatcom counties of Washington State (Figure 1).

Figure 1: Study area.

I develop an explanatory framework, drawing heavily on studies of ecological, and disaster resilience. I then use this framework to discuss participant-identified threats, vulnerabilities, and the means of adaptation among a range of agricultural producers. While I focus on the farmers' perspectives to develop an explanatory framework, this thesis is part of a larger research project (Berardi, Green, Hammond, & Ripley, 2009) seeking to understand adaptation and resilience in the agricultural sector.

In this thesis, I ultimately argue that the vicissitudes of agricultural markets, weather, and politics attract or develop individuals with greater abilities to adapt to adversity than other professions. Frequent exposure to unpredictable socio-economic circumstances builds a habit of adaptation, such that weathering change becomes part of the culture. However, the processes that build the habits and adaptive skill sets that benefit farmers over time appear to farmers more as a threat than a benefit.

1.2 Brief Outline of Thesis

In the next chapter, I present some background to the present research, discussing how scholars have understood the topics of vulnerability, resilience, and adaptation in small-scale agriculture. I first discuss vulnerability and how scholars have applied the concept in examining the roots of uneven hazard impacts. After situating this thesis within the vulnerability literature, I proceed to discuss four threats to Western Washington agriculture assumed by the present research: urbanization, rapid increases in energy costs, climate change, and flooding. I then discuss the concept of ecological and disaster resilience and how scholars use the term in the sense of adaptation as well as rebounding from disturbance with particular applications to agriculture.

In the third chapter, I discuss my methodology, by first describing my exploratory approach as a hermeneutical process. I then discuss the background research that went into designing the disaster planning workshops and the process of developing disaster scenarios with key agricultural sector informants. I describe the data collection at the workshops in which farmers responded to disaster scenarios previously posed in facilitated discussion of vulnerabilities and adaptive strategies. I then discuss the development of an analytical framework through which to understand farmers' perceptions of their own vulnerability within a larger agricultural and societal context, as well as possible means of adaptation therein. I conclude the chapter by discussing the iterative process of thematic coding and analysis within the analytical framework I developed.

In the fourth chapter, I present my results, supported by farmers' statements quoted from the transcripts. The results correspond to my original research questions in outlining what workshop participants view as threats and possible adaptive strategies. In the fifth chapter, I reflect on participants' comments within the ecological and disaster resilience literature before discussing what further research might advance knowledge of adaptation in the agricultural sector in general and in Western Washington State in particular. I then briefly summarize my previous analysis and discussion and present my concluding thoughts.

Chapter 2: Background

In this chapter, I situate the current research within the existing literature on threat and resilience in agriculture. I do so by first briefly discussing the agricultural geography, ecology, and farm production attributes of Western Washington State. I then introduce the concept of social vulnerability and how other scholars have examined its role in amplifying the effects of the disturbance on actors within the system. I then discuss the four threats this research posed as disturbance events, potentially disrupting system function in Western Washington. I conclude this chapter by discussing the concept of resilience as a means to understanding vulnerability, adaptation, and consequences of failure to adapt to the effects of disturbance events.

2.1 Agriculture in Western Washington State

Western Washington State has a long tradition of rural agricultural land use. This research focuses on San Juan, Snohomish, and Whatcom Counties since each has a slightly different history and challenge in agricultural production (Figure 1). Considered together, examination of the three illuminates issues that Western Washington faces more fully than considering only a single county. The counties are situated in a region that stretches from the waters of Puget Sound eastward to the foothills of the Cascade Mountains and from the northern urban fringe of the greater Seattle metropolitan area northward to the Canadian Border. Summers and winters are mild, with winters receiving the greater amount of rain and summers being drier. Annual precipitation in the Puget Lowlands averages 32 to 35 inches and 25 to 30 inches in the San Juan Islands (Chambers, 2002). The mainland has several major river systems, the Nooksack,

Snohomish, Skagit, and Skykomish, running from the Cascades to the Puget Sound, sourced with melt water from past seasons' snow fall in the Cascades. Much of the agriculture in Snohomish and Whatcom Counties occurs in the fertile floodplains of these river systems. The cool, moist climate supports a variety of agricultural production, though it favors berry, roots and bulbs, grass, and seed production (Chambers, 2002). Thus, due to ease of raising pasture and the lack of temperature-induced stress on cattle, dairy operations have held a prominent position within the rural landscape since European settlement.

Whatcom County occupies the northwestern extreme of the Washington State mainland, bordered by British Columbia to the north, the Strait of Georgia to the west, the Chuckanut Mountains to the south, and the Cascade Mountains to the east. The county population in 2010 was 201,140 (U.S. Census Bureau, 2010). Government, retail trade, healthcare, and manufacturing provide the most employment in the county (Center for Economic and Business Research, 2009). Agriculturally, Whatcom County is the largest dairy producer of the three study counties with a $186.5 market value of produced dairy products in 2007 (DeHaan, 2010). The largest agricultural product in the sector, dairying, accounts for 57 percent of Whatcom County agriculture's $326.5 million market value. Other significant products include fruit and berries (21 percent of total county market value) and cattle and calves (7 percent of market value). The majority of Whatcom County Agriculture occurs in the Western half of the county in the Fraser Lowlands, through which the Nooksack River runs.

Snohomish County has the largest population of the three study counties with 713,335 residents in 2010 (U.S. Census Bureau, 2010) and is situated immediately

north of greater Seattle, Washington State's largest urban area. Bordered by Puget Sound to the west, the Cascade Mountains to the east, and rural Skagit County to the north, the sectors providing the most employment to county residents are durable goods manufacturing, government, retail trade, and health services (Vance-Sherman, 2011). Snohomish County's agricultural production is less than half that of Whatcom County's, with $125.6 million in total market value. Major farm products are hay, truck vegetables and farm tourism, according to the 2007 Census of Agriculture (U.S. Agricultural Census, 2007).

San Juan County is the smallest of the three study counties in terms of area and population, as well as the least accessible. In 2010, the population was 15,769 (U.S. Census Bureau, 2010). The county is comprised of several hundred islands in the Puget Sound, between the mainland of Washington State and Vancouver Island, British Columbia. Transportation between the islands and the mainland is predominantly by Washington State Ferry, however, only the largest, most populous islands receive ferry service. The service-providing sector, including government, produces the most employment (Vleming, 2010). Of the three study counties, San Juan historically has had the smallest agricultural industry and continues to have the smallest with a total market value of $3 million in products sold, the majority being in animal products (San Juan Agricultural Resources Committee, 2009; U.S. Agricultural Census, 2007).

2.2 Vulnerability

Social vulnerability, in the natural hazards literature, is the means by which a disturbance event is translated into what might be called a disaster. It is important here to note that a disturbance event arising from a natural or technologic hazard and a disaster are different terms signifying different situations and are not necessarily linked. The United Nations International Strategy for Disaster Reduction (2009, p. 4) defines disaster as "a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceeds the ability of the affected community or society to cope using its own resources." While the disturbance "triggers" (Blaikie, Cannon, Davis, & Wisner, 1994) the events that become recognized as the disaster, it is important to examine the events, situations, and processes that produce the condition of vulnerability to the disturbance event that "triggered" the disaster. In other words, disasters are not inevitable. From a social vulnerability perspective, the disaster is not caused by the natural hazard itself; rather, the disaster originates in the societal forces of economics, ideology, and lack of adequate governance (Blaikie, et al., 1994; Steinberg, 2006). Such "root causes" (Blaikie, et al., 1994) shape human geographies over time, forming social hierarchies through relationships of power and exclusion. "Dynamic pressures" such as changes in debt repayment or rapid population growth place populations at risk by endangering their means of earning a livelihood (Blaikie, et al., 1994). A natural hazard then serves as the trigger event that releases these pressures that have been building over time (Blaikie, et al., 1994).

Thus, disasters are not "acts of God." Rather, they are produced from the historical social relations in the impacted region (Steinberg, 2006). Such historical social relations, over time, produce vulnerability, often most notably for marginalized and minority populations, thus building pressure to be released by a trigger event. Potential causes of vulnerability at the household level may entail the lack of formal education, reliance on one source of income, lack of savings, or low social standing in the community, with gender, age, and race also playing roles. Such household characteristics reduce coping capacity in the case of disturbance. For example, low education may inhibit knowledge of alternative livelihood strategies; one source of income increases the likelihood of losing all household income; little to no savings decreases the time to find alternative means of livelihood following disturbance; gender, age and race, depending on the culture in which the household is situated, may dictate the available resources, thus potentially decreasing household coping options. Indeed, the specific causes of vulnerability are complex. A full vulnerability assessment of the study counties, however, is beyond the scope of this thesis.

Recent examples of differences in vulnerability can be found in the 2010 earthquakes in Haiti and in Chile. Haiti, one of the poorest countries in the western hemisphere, suffered greater casualties and serious infrastructure collapse than did Chile, where buildings are more seismically stable and there exists a more durable and extensive infrastructure network.

Certainly there is a sizeable literature on social vulnerability dating back to the early 1980s (Adger, 2000; Blaikie, et al., 1994; Cutter, 1996; Cutter, Boruff, & Shirley, 2003; Davis, 2001; Pelling, 1999) with much of it focusing on the developing world

(Bankoff, 2001). In the United States, Cutter, et al. (2003) focus on examining geographies of vulnerability at the county level using an index based on eleven factors of social vulnerability. The counties of focus in the present research have lower vulnerability index scores, possibly because of the lack of a densely built environment, the factor of third-most importance in the index. The top two factors in Cutter, et al.'s (2003) social vulnerability index, however, are age and personal wealth. Such factors also correspond with growing concerns within agricultural communities of an aging population of primary operators and decreasing profit margins (USDA National Commission on Small Farms, 1998). However, in the context of the agricultural sector, age is more complex than Cutter, et al.'s (2003) index suggests, which focuses primarily on movement away from harm. While farmers in their twenties and early thirties certainly possess greater physical prowess than farmers in their sixties, younger farmers' lack of experience in a variety of environmental, legal, and economic circumstances potentially puts them at greater risk than more experienced, older farmers.

Other researchers have focused on specific instances of vulnerability in the agricultural sector of Washington. Fontaine (2007) examined vulnerability to drought in Washington State, finding that water law played a role in determining vulnerability. In Washington State, irrigators with junior water rights (meaning they acquired their rights after those with more senior water rights) are the first to lose regular access to water. Researching the farm labor force in the Skagit Valley of Western Washington, Holmes (2007) examines the vulnerability of berry pickers of indigenous Mayan ethnicity originating from the Mexican state of Oaxaca. Holmes discusses the

naturalization of their position in the hierarchical farm labor force. Holmes' study population is not visible on Cutter, et al.'s (2003) map largely because of its undocumented and uncounted immigrant status. However, Holmes' (2007) research corresponds with Cutter, et al.'s (2003) index factors in that race, ethnicity, and housing situations play a significant role in determining vulnerability to environmental disturbance. Little published scholarly literature on agricultural vulnerability in Western Washington State exists and the present thesis hopes to begin to fill this gap by examining farmers and their relation to the larger scales in which they are situated. As vulnerability is a complex phenomenon, with several factors acting in concert to adversely affect the individual or group unit, such an examination is appropriate in a sector where the "local" is linked to global markets and climatic patterns. Often the factors that increase or diminish vulnerability vary widely in scale and geographic location, such as global economic markets and localized environmental change (Adger, Eakin, & Winkels, 2008; Eakin & Luers, 2006). In a world that is growing more connected by the year, environmental, political, and economic events once far removed have the potential to alter a farm's operations or decrease its ability to persist.

2.3 Assumed Threats

Agriculture in Washington State faces natural hazards, such as flooding (Green, et al., 2008), drought (McChesney, 2001), landslides (Burke, Sattler, & Terich, 2002; Wegmann & Walsh, 2001), wildfire and severe storms (Washington State Division of Emergency Management, 2001), as well as anthropogenic threats (Jha, 2010), such as rapid increases in energy costs (Berardi, 2009), and urbanization (Klein & Reganold

1997). The present research concentrates on four threats in particular: climate change, flooding, rapid increases in energy costs, and urbanization. Such a selection balances hazards of human and natural origin as well as slow and rapid onset, thus allowing for greater ability to generalize the findings (Table 2).

	Anthropogenic	Natural
Slow Onset	Urbanization	Climate Change
Rapid Onset	Rapid Increases in Energy Costs	Flooding

Table 2: Onset speed and type of hazard.

2.3.1 Urbanization

Agricultural land in Western Washington has been slowly disappearing to urban encroachment for decades and the region now supports the most densely populated area of the state (Klein & Reganold, 1997). Over the two decades prior to Klein and Reganold's study (1997), farmland west of the Cascades declined at a higher rate than Washington State as a whole. In addition to a 16 percent decline in Western Washington farmland acreage, the number of farms decreased by 20 percent. Moreover, most farmland lost in Western Washington was owned by operators themselves (Klein & Reganold, 1997). As the population of the region continues to grow and the demand for residential housing increases, land values increase, placing greater pressure on agricultural uses. Higher prices exclude new farmers from purchasing land because the value of the crops produced would not allow the farmer to service the debt incurred from purchase. Farmers themselves are seeking alternative uses of this land, realizing

great profits from subdividing and selling farms or portions of farms for non-farm use despite a desire to keep rural land in agricultural use (Schiller, 2007).

Though farmland preservation plans and programs are popular (Municipal Research and Services Center of Washington, 2010), as is public sentiment favoring the preservation of farmland as open space (Davis, Hibbitts, & Midghall, 2009; Whatcom Farm Friends & Grey, 2008); farmland attrition continues. This, despite the fact, that during the late 1980s, the state of Washington came to view chaotic growth and unplanned land use as detrimental to quality of life, in leading to the passage of the 1990 Growth Management Act (GMA) RCW 36.70A as a means of coordinating land use and growth in such a way as to reflect fourteen specific goals aimed at maintaining or improving quality of life (Growth Management Hearings Office, 2009). Several of these goals place value on maintaining open space, natural resources, and the environment in the form of agricultural land. While the Growth Management Act addresses concerns of urban expansion to agricultural lands, urbanization threats to farmland do persist (Klein & Reganold, 1997; Lehman, 2009). Further, local planning departments do not have an adequate system for monitoring land conversion to non-agricultural uses (Klein & Reganold, 1997).

2.3.2 Rapid Increases in Energy Costs

Since the end of World War II, the system of agricultural production in the United States has industrialized and grown increasingly reliant on inexpensive sources of external energy, primarily in the form of fossil fuels (Roberts, 2008). Fossil fuel-based energy is used to propel tractors, combines, and the other field implements

needed to operate at the scales required to competitively farm commodities such as corn, soybeans, and wheat. Fossil fuels provide the energy needed to transport foods between sites of production, processing, and consumption. Petroleum is also critical in manufacturing pesticides and fertilizers, upon which much of the sector has grown reliant (Roberts, 2008). Further, as mechanization has replaced the need for manual labor, the United States production system has become increasingly linked to international energy markets. This allows geopolitical events such as the oil embargo of 1973, when petroleum prices doubled within an 18-month period (Carter & Youde, 1974), to exert greater influence over the agricultural sector, and thus the United States rural economy.

Recent work has shown that the United States and Washington State are still exposed to this threat (Berardi, 2009). Conventional fertilizer and diesel fuel price likely would be directly affected by fuel shortages; however, other indirect effects would likely influence farms and the rural economy further such as high energy costs, which are often linked to recessions, which may affect the rural economy.

2.3.3 Climate Change

The effect climate change will have on agriculture is not certain; however, given the linkages between climate and agricultural production (Kruger, 2008; Russo, 1978), any effects are likely to be important. Variations in weather are responsible for a significant majority of the variation in crop production (Russo, 1978) and may actually constitute as much an opportunity as a threat. Climate change will likely heavily affect water availability in Washington State (Kruger, 2008). While annual precipitation is not

expected to change significantly (Washington Department of Ecology, 2006), the possibility of raised temperatures may result in a decreased winter snowpack, correspondingly decreasing available water during dry summer months, and increasing the likelihood of flood events with less water held in snow until the warmer months. This would mean drier dry months, and wetter wet months.

Another possible impact would be the change in pest life cycles (Kruger, 2008). Warmer temperatures would potentially allow pests to reproduce more quickly, as well as survive through seasons where low temperatures have historically killed or forced them into hibernation.

2.3.4 Flooding

The floodplains of the Nooksack, Snohomish, Chehalis, and Skagit rivers all encompass regions with significant agricultural output. Flooding remains a serious threat for many areas of Western Washington State. The majority of precipitation falls during the winter, swelling the river systems with frequent minor flooding. Major flooding occurs often, however, with Western Washington having experienced eleven major flood events since 1990. In 1990, farmers in the Snoqualmie Valley lost over 500 head of livestock as well as feed grain (Department of Natural Resources and Parks, 2008). The 2007 flooding of the Chehalis River left debris as well as significant amounts of silt in farmers' fields. Farmers lost an estimated 1,600 head of cattle (Garber, 2007) because they lacked adequate evacuation plans before the floodwaters rose (Green, et al., 2008).

2.4 Resilience

To decrease the complex effects of hazard events on vulnerability, scholars have advanced the concept of resilience (UNISDR, 2009). Whereas vulnerability tends to emphasize the structural attributes that place groups and individuals at risk, resilience frameworks focus on strategies that allow individuals and communities to adapt to change. Resilience frameworks focus holistically on "systems," taking into account how different system aspects and their interconnections form a whole unit, rather than reducing a system to its component parts. Such "systems" range in scale from an individual (Marshall, Fenton, Marshall, & Sutton, 2007) to an ecosystem (Holling, 1973, 2001; Nystrom & Folke, 2001). Carpenter, Walker, Anderies, and Abel (2001) define resilience in terms of system flexibility, a system's ability to maintain control over itself, and the capacity the system has to adapt to change. The hazards literature on vulnerability is linked to events that trigger underlying pressures and unsafe conditions (Blaikie, et al., 1994). The concept of resilience thus is inherently related to disturbance events, where resilience is a measure of the degree to which a system retains the same basic structure and function (Cumming, et al., 2005; Eakin & Luers, 2006) despite the disturbance**.** In these terms, a resilient system would be able to experience disturbance and adapt while retaining the same basic structure and function as prior to disturbance.

Researchers have used the concept of resilience across a range of disciplines, examining a variety of topics, such as ecology (Holling, 1973, 2001; Nystrom & Folke, 2001; Walker, Holling, Carpenter, & Kinzig, 2004), sustainable agriculture (King, 2008; Milestad & Hadatsch, 2003), food security (Alinovi, Mane, & Romano, 2009), disaster

studies (Bruneau, et al., 2003; Manyena, 2006; Norris, Stevens, Pfefferbaum, Wyche, & Pfefferbaum, 2008; Rose, 2004), homeland security (Kahan, Allen, & George, 2009), natural resource management (Berkes & Jolly, 2001), and historical development (Langridge, Chrisian-Smith, & Lohse, 2006). Ecological studies within a resilience framework tend to examine the ability of a system to persist (Holling, 1973) despite disturbance through species diversity (Gunderson, 2000; Peterson, Allen, & Holling, 1998) and adaptation. Agricultural, food security, disaster and homeland security studies using resilience frameworks examine systems in which humans play a significant role, asking how some communities, households, and individuals thrive despite frequent disturbance. Such studies aim to increase understanding of the ability to thrive despite disturbance and build the potential to transform (Walker, et al., 2004) non-resilient systems into resilient systems. In a broad study examining such academic traditions as they relate to disasters, Norris et al. (2008) find that community resilience depends on "population wellness." Enhancing such wellness includes maintaining community flexibility, ensuring equitable access to resources and social support, and increased linkages between organizations, creating overlapping and reciprocal relationships. Lastly, resilience studies in natural resource management have focused on adaptive governance structures and the degrees of inclusiveness and flexibility in addressing issues of who has access to a resource such as a river or other water source and who benefits from its use (for example, see Olsson, Folke, & Berkes, 2004).

The major assumption underlying resilience-focused studies on agricultural issues concerns the connection between human and natural systems: agriculture represents an area of activity where society's altering of the natural world to its benefit

is most visible. Jackson and Piper (1989) argue for 'the necessary marriage" of ecology and agriculture, where a holistic approach should examine entire systems. For example, researchers have examined the interaction between agricultural production and eutrophication in freshwater lakes through a resilience framework (Carpenter, et al., 2001). Such a study addresses how human actors affect the natural system in which they are situated, and how the natural system affects the human actors. However, Carpenter, et al.'s research focused on the resilience of turbid and clear-water states in lake water quality, with non-point agricultural pollution as one of the driving variables, rather than the agricultural operations themselves. In this study, Carpenter, et al. (2001) conceptualize agricultural activity as the disturbance influencing the freshwater lake water quality. Such a study features the inclusion of agricultural activities within the socio-ecological system and possible constraints to farm-based adaptation. As a possible cost-reduction strategy at the farm scale, less stringent nutrient management practices disturb the social infrastructure at the community scale. Such transferring of problems from farm to community potentially creates feedback in the form of more strict regulation of nutrient management practices to ensure nutrient management issues are dealt with at the farm scale. More stringent regulations take a greater amount of effort and time to demonstrate compliance on the part of the farmer.

In studies examining agriculture itself through a resilience framework (Allison & Hobbes, 2004; Berardi, et al., 2009; Keil, et al., 2008; King, 2008; Langridge, et al., 2006; Milestad & Hadatsch, 2003), drought has received the most attention. As a disturbance regime, drought affects agriculture more widely than do other natural events such as wildfires, earthquakes, and cyclonic storms. Keil, et al. (2008) examine crop production

and household resilience to drought in Central Sulawesi, finding that assets, access to credit, and efficient use of inputs, such as water and fuel, play strong roles in determining the resilience of households. In this study, resilience is considered the ability to maintain the same standard of living by continuing to consume high quality foods of fish and meat and expend similar resources on basic necessities such as clothing, housing, and health care, despite prolonged drought conditions. The authors' recommendations for enhancing household resilience include increasing access to credit, improving financial management, and intensifying extension services aimed at increasing production efficiency. Along a similar vein, Ranjan and Athalye (2008, p. 438) conceptualize resilience to droughts as "pertaining to the ability of the farmer to continue farming despite decreasing water supply." Factors determining farmer resilience in this study include technological "fixes" to more efficiently use water, as well as perception of drought risk and vulnerability. Perception of drought risk and vulnerability influences to what extent farmers prepare for drought events, as well as to what extent farmers are willing to adopt new technologies. Perception of lower risk and vulnerability leads to lower preparedness and less investment in water saving technology (Ranjan & Athalye, 2008).

Swanson, et al. (2009) address adaptive capacity to climate change in the Prairie Provinces of Canada using aggregate Census Canada data and defining adaptive capacity as the means to deal with exposure to a disturbance event. The authors identify such means of adaptation in agriculture as consisting of: economic resources available to take advantage of a greater range of options, the ability and savvy to adopt technological solutions to persistent problems, access to timely and relevant

information, access to reliable infrastructure, social networks and institutions that aid in adaptation, and fair distribution of resources. The study found that agricultural areas around population centers displayed a higher adaptive capacity, due in part to better information networks and water infrastructure, more off-farm employment opportunities, more extensive transportation networks, and greater access to outreach from institutions of agricultural education.

Myers (2008) focuses on responses to weather-related shocks over the period 1999 – 2005 in the Canadian Prairie Provinces, finding that the aging agricultural labor pool and poor market prices contributed to decreased motivation to employ long term strategies for adaptation and conservation. Short-term responses were guided by parochial economic motivations rather than holistic considerations for consequences in larger socio-ecological systems. Although he does not explicitly state it, Myers (2008) leads the reader to believe short-term survival may be at the expense of long-term resilience.

Milestad and Hadatsch (2003) discuss the "desired system state" of farmers in the Sölktäler Valley of Austria and organic farming as a means of maintaining that system state. The authors make a distinction between resilience and sustainability by stating that the latter contains assumptions as to the desirability of the system. By contrast, an undesirable system can be resilient, just as a desirable system can lack resilience. One goal of the alpine farmers in the study was to maintain traditional methods of production that encouraged both economic stability and the persistence of ecosystem services. The authors use a resilience framework as a means of organizing the interactions between the European Common Agricultural Policy (CAP), which

strongly encourages organic farming through financial support, and the desires of the local farmers. Threats to the viability of farms in the form of tightening profit margins, decreasing employment, and greater emphasis on the aesthetics of agricultural landscapes rather than working landscapes concerned farmers of the Sölktäler valleys. Unlike the farmers in Myers' (2008) study, the Austrian farmers see short-term economic viability and long-term ecosystem services as connected, and thus view subsidized organic farming as a means of maintaining the desired agricultural landscape.

Allison and Hobbes (2004) use the adaptive cycle—a larger cyclical metaphor describing the ebb and flow of resilience over time through varying amounts and timing of social, ecological, and financial capital accumulation and release (Gunderson & Holling, 2002; Holling, 2001)—as a vehicle for understanding the forces driving changes in land use in the Western Australian agricultural region. Also examining the historical aspect of resilience, Langridge et al (2006) argue that social resilience is created by historical processes that determine access to a vital resource, such as, in the case of four communities in California, the acquisition and securing of water rights. Thus, in their conceptualization, resilience is the opposite of vulnerability.

Much of the literature on ecological resilience is predominantly theoretical. The literature in disaster studies focuses on understanding the individual, community, and societal processes that enable rapid recovery from disturbance and long-term adaptation. Difficulties in these two approaches arise due to the complexity of the ecological theory and the myriad unique place- and culture-based practices that allow certain communities and individuals to thrive despite disturbance. Walker and Salt

(2006), in fact, argue that the key to understanding resilience is in the changing of an individual's, community's, or society's methods of thinking of and relating to socio-ecological systems.

This present thesis is an attempt to shed light on place- and culture-based practices while continuing the larger discussion of how workshop participants think of and relate to the socio-ecological systems in which they are embedded. To this purpose, I draw from these prior studies and define resilience as a socially and historically contingent characteristic (Allison & Hobbes, 2004; Langridge, et al., 2006) of socio-ecological systems describing a farm's ability to persist (Holling, 1973, 2001) by adequately responding to disturbance and adapting to change (Swanson, et al., 2009), and at the same time maintaining a desirable standard of living over extended periods of time. In the context of farmers in Western Washington, a resilient farm would remain in agricultural production, providing all or part of the livelihood of the farmer and his or her family; and finally, maintaining land in agricultural uses does not burden individuals or the communities in which it is situated.

Chapter 3: Methodology

In this chapter, I discuss the methodology employed in this thesis. I first describe the hermeneutic approach I take to the research problem of how farmers understand threats and adaptation in relation to their operations and the wider agricultural sector and socio-ecological system. I then discuss the disaster-planning workshops from which I drew my data and briefly explain their basis within a larger USDA–funded research project. In the next section, I discuss the iterative process of analytical framework development and subsequent thematic analysis that assists in the explanation of how the farmers understand threat and adaptation.

3.1 Research Approach

I have approached this study through what can best be described as a hermeneutical process. "Hermeneutic approaches aim at understanding and are founded on interpretation as the primary form of knowledge" (Ödman, 2007, p. 113) and as such are suited to seeking a deeper understanding of how farmers view threats and adaptation in the agricultural sector. Regardless of whether the product of this study ultimately is measurable or is "existential" and thus immeasurable (Ödman, 2007), a process of moving between early understanding, interpretation, understanding, and explanation (Ödman, 2007, pp. 117 - 119) best describes how I approached this study.

Using a hermeneutic approach to research problems examining resilience in agriculture is not entirely new. Milestad (2003, p. 20) discusses her study of resilience in a rural agricultural area of Austria as a "hermeneutic spiral," where she methodically

worked through her assumptions, theoretical framework, approach, methods, and analysis. Similarly, I have moved along a cyclic and iterative path through my early understanding of agricultural issues in Western Washington State, my assumptions concerning resilience theory, my reading and questioning of the literature, my observations and interactions with farmers during the disaster-planning workshops, my interpretations of these observations, subsequent understanding and attempted explanation, and re-examination of earlier work. As I wrote this thesis, I continued this cycle of early understanding to explanation, in that my understanding prior to this writing influences my written explanation that in turn influences my understanding. Upon revision, this new understanding becomes early understanding and through interpretation and explanation begins the cycle again.

3.2 Scenario Development and Culminating Workshops

This thesis is part of a larger United States Department of Agriculture-funded project aimed at "Enhancing Resilience in Small and Medium-Sized Farms" using scenario based planning (Berardi & Green, 2008). The project builds on the assumptions that small- and medium-sized farms[1] play an important role in the Western Washington regional economy and culture and that the regional agricultural sector faces increasing threats in the future. Such threats can be planned for and mitigated by enhancing individual farm and community resilience.

[1] The USDA defines small- and medium-sized farms as farms having less than $250,000 in sales. Large farms are defined as having sales between $250,000 and $499,999. Very large farms have sales greater than $500,000 (USDA, 2005).

Four scenarios of likely threats—rapid increases in energy costs, climate change, flooding, and urbanization— were developed between June and December of 2009 through consultation with key informants and considerable background research. Each scenario incorporated relevant literature and was written to portray a likely, plausible event. Initial drafts of each scenario were first crafted generically for Western Washington through background research of each threat in relation to the agricultural geographies of the region. Then, with the assistance of key informants within each county providing feedback on localized concerns and situations, scenarios were revised and customized to be county-specific. Thus, beginning with scenario development, this research has followed an iterative process of exploration and validation. The scenarios were ultimately presented in narrative form only—without the extensive references and footnotes—at disaster-planning workshops[2] with groups of farmers operating small- and medium-sized farms in San Juan, Snohomish, and Whatcom Counties of Washington State in February of 2010 (Figure 1). Workshop participants were selected to represent a mix of agricultural producers from each county, age, experience level, geographic location, and marketing strategy. Such a mix was intended to offer robust and diverse participant input rather than to produce data to determine statistical significance to extrapolate to larger populations. Of primary importance was to capture and explore a range of characteristics given by farmers themselves.

[2] A human subject research exemption was obtained prior to contact with study participants. The author's certificate of completion of the National Institutes of Health Office of Extramural Research course "Protecting Human Research Subjects" is located in appendix A.

Participants were selected as follows: first, primary agricultural products (based on USDA census of agriculture data) of each county were determined. A list of potential participants from each county then was generated and vetted by Washington State University Agricultural Extension and agricultural sector non-profits in each county. Then, each potential participant was contacted by telephone. Candidates who agreed to participate received confirmation verbally and through email, followed by an information packet, containing workshop goals, operative definitions of key terms, and the relevant disaster scenarios. As candidates agreed to participate, selection efforts shifted to ensure adequate and proportional representation of each county's primary agricultural products. In total, 44 farmers participated in the workshops, each receiving a stipend of 75 dollars for his or her time, and signing a consent form authorizing researchers to use non-attributed remarks in reporting and writing journal articles. The total number of participants reflects a significant commitment of time in a population that rarely takes time away from work for themselves. In studies similarly examining stakeholder perspectives on a particular issue or sense of place within a larger context, the total number of participants is comparable or less than the present study. For example, Alper and Hammond (2009) examine the perspectives of 46 stakeholders on management of the international border between Washington State and British Columbia, Canada. Atwell, et al. (2010) examine tradeoffs between ecosystem services and food and energy production through a participatory workshop and follow-up interviews with 14 leaders working in the Iowa agricultural sector. Among Huxley College graduate projects, Dear (2001) examined understanding of subsistence among 30 recreational users of the Gates of the Arctic National Park, while Copeland (2001)

examined women's sense of place in the Stehekin area of the North Cascades National Park through interviewing nine participants. Not only is the total number of participants in the present study adequate to meet the goals of this research, the participation rate is similar to reported rates in scholarly literature at Western Washington University and elsewhere.

Each disaster-planning workshop was conducted by a professional facilitator and guided by research team input developed through prior workshop planning sessions. During the months prior to data collection, researchers met with the facilitator multiple times to discuss goals, workshop design, and the theoretical underpinning of the research. Workshop design and rationale were developed, discussed, criticized, and revised prior to agreement on a final agenda, discussion structure, and participant packet to ensure that data-collection goals were met. Workshop discussions were digitally recorded while individual researchers observed and took notes. Recordings were transcribed in full and notes were typed into documents for later analysis and triangulation.

Workshops, one per county, lasted between 5.5 and 7.5 hours. Participants registered and signed forms agreeing to participate and allowing the researchers' use of workshop discussions as non-attributed quotes before the workshop began. Each workshop followed the same format: an introduction to the concept of resilience and two sample cases highlighting different aspects of the concept followed by the presentation of disaster scenarios and subsequent small-group discussion. Each participant received a set of prompts for discussion concerning challenges, needs, resources, and long-term impacts likely to affect adaptation. As the researchers and

facilitator presented a different scenario, participants were encouraged to switch small groups for maximum interaction among producer types. Researchers also alternated between tables while taking notes to observe all participants. Each workshop concluded with a full group discussion of the commonalities across scenarios.

Following the completion of the workshops, all recordings were transcribed in full by a professional transcriber and separately analyzed by theme by individual researchers. In the initial, open coding phase (Strauss & Corbin, 1990), I noted and assigned preliminary codes to patterns (Gustavsson, 2007) that I saw within participants' conversations regarding their perception of threats and the means by which response and adaptation were possible or hindered. Themes with both high and low frequencies were noted and included during this phase of coding. In total, I noted 18 themes in San Juan County, 16 in Snohomish County, and 23 in Whatcom County. Through these initial themes and through consideration of the resilience and vulnerability literature, I developed an analytical matrix through which to interpret the transcript data. In the next section, I describe the development of the analytical matrix and then conclude this methods chapter with a section discussing the process by which I used the matrix as a lens to identify and cluster themes that emerged from the workshops.

3.3 Framework

In this thesis, I develop a framework through which to analyze farmers' perspectives on vulnerabilities to their operations and the sector, their suggested strategies for adaptation, and their perception of their role within the varying scales of

reference. Drawing heavily on the resilience literature while also noting the transcript themes, I developed a matrix through which to analyze workshop participants' views of vulnerability and adaptive strategy (Table 3). The resulting threat and adaptation analytical matrix can thus be used as a framework to analyze and discuss the present data within the larger literature on resilience, vulnerability, and adaptation. In the following several pages, I will discuss the importance of scale and each category within the literature and the relevance to the current research.

Scale and Thematic Category	System	Threat	Threshold	Adaptive Strategy
Individual Farm Scale				
Community / Network Scale				
Food System / Policy Scale				

Table 3: Threat and adaptation analytical matrix.

3.3.1 Scale

The interplay between spatial and temporal scales is one of the central concepts of resilience approaches (Folke, 2006), thus scale becomes an important aspect of a resilience analysis. As processes occurring at one scale affect processes occurring at another, a holistic analysis must allow for the possibility of such cross-scale

interactions. For example, the life cycles of the spruce budworm and the trees of the North American forests in which they live occur on two different temporal scales, yet feedback between short-lived insect and the long-lived tree can have significant and long lasting effects on the entire system in which both insect and tree are embedded (Folke, 2006). Likewise, events and processes occurring at local scales within the agricultural sector influence events and processes at larger scales. On a macro scale, Hart (2003) describes the interregional migration of dairy operations from the west coast to the intermountain west, driven by rents, the cost of production, and increasing urban encroachment, all happening locally at the community scale. Thus, an event removed in space and time from an individual or community influences the individual's or community's functioning. Such influences are visible at the macro scale, but may not be apparent at smaller scales of analysis.

In the case of the present research, I have focused on three interconnected scales in particular: the micro level or farm scale, the meso level or network scale, and the macro level or food system scale. Each scale represents a system in itself, though together they encompass a larger, nested system. As such, changes to existing regulations occurring at the policy scale affect the two lower scales by creating opportunity for some operations while imposing barriers on others. Conversely, management choices on one farm can have effects throughout the network in which that farm is embedded and eventually influence changes at the macro level that will in turn affect operations at lower scales and in different geographic areas. For example, a dairy farm may use the herbicide aminopyralid to manage broadleaf weeds in its fields, and inadvertently affect operations within its network and community. The herbicide is

not toxic in low concentrations to humans or animals, but when ingested and excreted by dairy cows, it remains in the manure (Burrows & MacConnell, 2010), which is then transported to farms and nurseries and used as fertilizer. Those operations using the tainted manure suffer losses in the form of wilting and reduced or no harvestable production. Such events may possibly lead to regulations limiting the use of aminopyralid, thus affecting the dairy farmers using it in broadleaf weed management, possibly even bringing into question certain components of the USDA organic rules.

3.3.2 System

As attention to scale and the possibility of interscalar interactions is vital to a resilience analysis, it is equally necessary to define the system that is or is not resilient (Carpenter, et al., 2001; Cumming, et al., 2005). Resilience is a measure of a system's ability to persist through adaptation, self-organization, and learning and one macro scale system can encompass several smaller scale systems. While the macro system could theoretically be resilient, not every smaller-scale system comprising it is necessarily resilient (Carpenter, et al., 2001). The resilience of one smaller scale system may mean the lack of resilience in another smaller scale system, while the overall macro level system maintains the ability to persist. Thus, it is necessary to describe and discuss the system and its components in question.

Such a discussion also serves to mark the identity (Cumming, et al., 2005) of the system in question through description of the relationships between the actors and objects within the system. Noting system identity is important in two respects. First, system identity serves as a baseline from which change or adaptation can be compared.

And second, description assists in sorting out which system's resilience is of prime concern.

With respect to the current research, I am interested in how farmers view their own vulnerability, as well as the larger sector's, their suggested means of adaptation, and how they perceive their place within different scales of the agricultural sector. Thus it is necessary to discuss system identity at all the three specified scales. Ultimately, it is the farm scale that is the focus of this thesis, though because of the influences of the network and food system scales on the farm scale, it is necessary to discuss all three.

3.3.3 Threat

Drawing on the hazards literature, I use the term threat to signify an event, process, or action that exacerbates, "triggers" (Blaikie, et al., 1994), or otherwise has the potential to release the underlying vulnerabilities within a geographic area or group of people. In the case of this research, a threat has the potential to do harm to the system in question. Correspondingly, the resilience literature focuses on disturbance as an event or events that stress a system. As discussed above, resilience is, on one level, the measure of how much disturbance a system can absorb without changing in structure and function (Carpenter, et al., 2001; Walker, et al., 2004). As perceived by workshop participants, a threat is a potential disturbance event with the potential for shifting the system to a different state. Thus, I take a broad view of threat in this research, giving the participants latitude in what they designate as a potential threat to the persistence of their operations. While four narrative scenarios of likely disturbance events in Northwest Washington prompted the data this thesis uses, I note the threats and

vulnerabilities identified by the farmers within the context of the workshops. Additional threats, aside from the four assumed and presented as scenarios, emerged through participant discussions.

3.3.4 Threshold

Just as identifying and discussing system identity, scale(s) of analysis, and disturbance events that threaten the system, thresholds, also represent a key component in resilience analysis. Introduced by ecologist C.S. Holling (1973), a threshold denotes a transition point where the dominant relationships and processes structuring a system change to a different state, thus changing the system. For example, Carpenter, et al. (2001) discuss the levels of phosphorous and oxygen in freshwater lake water and sediment. At a certain point in phosphorous accumulation, due to high animal densities on farms within the watershed, the lake is no longer able to maintain a clear water state, crosses a threshold, and then enters a turbid state. Either state can be resilient; the threshold represents the point of division between the two. While not central to my research questions, I briefly include thresholds in this thesis for three reasons. First, the idea of a threshold as a point of transition between one system state and another is prevalent in the resilience literature. Second, the larger research project, of which this thesis is a part, seeks to identify possible points of transition to where farming is not longer possible. Third and most importantly, workshop participants identified possible points of transition, though at times vaguely, beyond which farming at the individual farm scale and community scale would qualitatively change or be no longer possible.

3.3.5 Adaptive Strategy

The final category in my analytical framework pertains to suggested strategies as a means to counter perceived threats and avoid thresholds where the transition is to a less desirable system state. Adaptive capacity, as the concept is commonly termed in the resilience literature (Allison & Hobbes, 2004; Carpenter, et al., 2001; Robards & Alessa, 2004; Swanson, et al., 2009; Walker, et al., 2004), is an individual or system's ability to adapt to changes in the environment in which it is embedded. Conceptualizing the resources that comprise the possessed ability to adapt, Swanson, et al. (2009) use readily available aggregate data from Census Canada to measure the adaptive capacity of agricultural regions of the Canadian Prairies and identify those areas theoretically best able to adapt to future climatic changes. Such a method focuses on measuring the current ability to adapt to climate change based on the authors' notions of resources required for adaptation, focusing on scholar-specified aspects of the system, such as economic resources, infrastructure, and technology. In contrast, the present thesis focuses, not on measurement of adaptive capacity as theorized by scholars, but on strategies suggested by farmers themselves. The present research rests on the assumption that farmers are experts in their field, the field of managing their farm operations and producing their particular product (Baars, 2010). By focusing on strategies for adaptation rather than characteristics describing the capacity to adapt, this framework hopes to build on past attempts at measuring adaptive capacity and introduce new avenues to expand on past research approaches while collecting potential strategies for adaptation.

3.4 Thematic clustering within the analytical matrix

Following development of the analytical matrix through review of the resilience literature, initial thematic coding, and theme validation through other project researchers' identified themes, I returned to the transcript data and recoded them by scale and category as delineated in the matrix. I extracted the coded segments of the transcripts through querying each category at each scale using NVivo 8 qualitative analysis software (Wong, 2008). I then re-examined the data in the context of the analytical matrix, writing a four-to-seven word phrase summarizing the salient point of each segment in a separate document. I then repeated the process examining the four-to-seven word phrases looking for and noting similarities. As clusters of similar ideas began to emerge, I grouped similar themes and gave clusters one to three word names (Table 4), with two or three clusters occupying each part of the matrix. Smaller groupings received less attention and ideas that stood alone were discarded. Such methods follow a similarly qualitative approach as Atwell, et al. (2010) use in identifying barriers and opportunities in enhancing ecosystem services in rural Iowa.

Such an approach is appropriate in the case of examining farmer perceptions of vulnerability and adaptive strategies in Northwest Washington State. Although there is a rich, developing theoretical literature on resilience and a mature literature on hazards and vulnerability, no frameworks exist to adequately analyze how farmers perceive vulnerability and adaptation within the larger system in which they are embedded while maintaining the qualitative richness of their own language. Through my method of developing an analytical matrix appropriate to the data by drawing on the literature, then clustering emergent themes within its context, I am able to demonstrate the

overarching ideas of farmers (Table 4) within three counties of Washington State while maintaining the richness of their individual responses all in the context of the larger literatures on resilience and vulnerability (Fereday & Muir-Cochrane, 2006). In deed, the rich preliminary results enabled project researchers to identify further threats for continued research and follow up.

In total, the methodology employed in this thesis follows Chambers' (1983) guidance that a research project must be performed fast enough so that the information collected is still relevant, efficient enough so as not to drain critical resources, and focus on improving conditions on the ground for the subjects of the research. Such an approach is possible through adequate preparation and research design.

Table 4: Theme frequencies by scale and category.

Scale	**System**	-	**Threat**	-	**Threshold**	-	**Adaptive Strategy**	
	Emotional	34	Economic	35	Death	5	Personality	44
	Economic	13	Dependency	33	Transition	2	Economic	34
Farm Scale	Geographic	9	Lack of Time	20			Technical	24
			Ownership and Succession	8			Multiple Skill Sets	17
							Planning	10
	Infrastructure	19	Social Infrastructure	37	Loss of Infrastructure	15	Network	27
Community Scale	People	13	Physical Infrastructure	36			Community	24
	Relationships	12					Relationships	13
							Social Infrastructure	5
							Physical Infrastructure	4
	Government Policies	21	Regulations	56	*Vague*		Support	28
Food System Scale	Economic	16	Uncertainty	30			Public Education	17
	Public Ethos	15	Paradigmatic	30			Interns / Next Generation	7
	Climate	7						

Chapter 4: Results and Discussion

In this chapter, I present the results of my analysis, delineated by scale (Table 4), beginning with the farm scale, and progressing up to the food system scale. The figures provided in the tables represent coded segments of workshop transcripts. Segments varied in size, from a single sentence to a paragraph explaining an idea at length, and participant engagement, from a single participant's comment to an exchange between two or more participants. Each coded segment, despite its size, represents a single occurrence of an idea. Discussing coded segments by scale allows for particular attention to how farmers are situated within the larger scales and their perception in how these scales influence their operations and range of options for adaptation.

Thus, the picture that emerges from the thematic analysis framework of the workshops described above is one of farmers interacting with and attempting to manipulate the socio-ecological system within which they are situated at different scales as a means to achieve persistence. Farmers' vulnerabilities differ by scale, by production style, by situation within a larger socio-ecological system, and by the decisions they have made in the past. Adaptive strategies also differ by scale, ranging from expanding a farmer's skill set to participating in government programs facilitating innovation and competition. Farmers thus navigate socio-ecological systems according to the characteristics of each scale. For example, at the individual farm scale the system is comprised of the farm's geographies and the farmer's emotional attachment to the land and lifestyle. Farmers attempt to manipulate the financial characteristics of the operation in employing strategies to adapt to issues threatening farm persistence. At the network and community scale, farmers interact with neighbors, networks, and

communities through physical, social, and organizational infrastructure. Social infrastructures constitute critical means of support in individual farm adaptation. At the food system and policy scale, farmers interact with climate, government policy, public paradigms, and a globalizing economic system, attempting to navigate uncertainties and persist. A resilient farm or farmer is able to successfully navigate challenges at the different scales, facing threats, taking advantage of opportunity, and employing adaptive strategies to avoid crossing a threshold to undesirable consequences.

Workshop participants spoke from experience about navigating the different scales, and suggested potential threats, thresholds, and adaptive strategies in their operations. I begin this discussion of my results at the individual farm scale, discussing the system at this level before moving on to threats against individual farms, thresholds at the farm scale, and adaptive strategies for farm persistence. I then discuss the network or community scale, within which individual farms are situated, followed by threats to the agricultural sector in San Juan, Snohomish, and Whatcom Counties at this scale, as well as thresholds, and adaptive strategies networks and communities might take. I finish this chapter by discussing the larger food system scale that influences the individual farms and communities situated within. I discuss the factors participants perceived as threats to their operations at this larger scale, potential thresholds, and adaptive strategies that might be employed.

4.1 Farm Scale

In this section I report on and discuss the dominant themes emerging at the farm scale (Table 5). The strongest discussion focused on attributes unique to the farmer and his or her relationships with the land and consideration of his or her occupation as a farmer. These themes emerged strongly in all counties, however Snohomish participants, in particular, focused upon their relationship to the land, the farming lifestyle, and the idea that the personal tenacity of a farmer predominantly accounts for a farm's resilience. Themes of economic viability also emerged strongly across all three counties.

Scale	System	-	Threat	-	Threshold	-	Adaptive Strategy	-
	Emotional	34	Economic	35	Death	5	Personality	44
	Economic	13	Dependency	33	Transition	2	Economic	34
Farm Scale	Geographic	9	Lack of Time	20			Technical	24
			Ownership and Succession	8			Multiple Skill Sets	17
							Planning	10

Table 5: Farm scale theme frequencies.

4.1.1 System

Farms are individual systems themselves and participants saw them as consisting of a mix of geographic (9 coded instances), economic (13 coded instances), and emotional factors (34 coded instances). Participants felt more in control interacting with and manipulating the socio-ecological system at the farm scale and were able to discuss constituent parts of the system in concrete terms. Geographic factors related to seasonal temperature and rainfall variability due to topography and proximity to either the Cascade Mountains or the Puget Sound coast. With respect to financial factors,

farmers discussed their unique debt loads; some had a heavy load and others had the entire operation paid for. Emotional aspects such as memories of growing up farming, attachment to the occupation, and pride in continuing farming despite encountering difficulties, were also unique to each participant and arose consistently across all counties. These aspects formed a part of the farmers' identity and included attachment to the farmland and lifestyle and a sense of independence and pride that participants felt set them apart from other people.

4.1.2 Threats

Within the socio-ecological system at the farm level, participants identified threats to the viability and persistence of a farm in terms of economic factors (35 coded instances), dependencies on off-farm inputs (33 coded instances), lack of time (20 coded instances), and ownership and succession (8 coded instances) themes. Many of these threats arise from larger scales in which the farm is situated; however, threats also arise from within the farm scale itself. In this subsection, I begin to answer my first research question of what makes farmers vulnerable to urbanization, climate change, rapid increases in energy costs, and flooding in relation to the farm scale by discussing farmers' views on threat at this scale and illustrate the themes by quoting participants' comments from the transcripts.

Participants discussed varying economic factors as the most threatening to their operation's viability. Several aspects of the cost of doing business constituted the most salient threats in participant comments, where the flexibility to switch production regimes depends on the ability to finance such adaptations and, only after production,

in general, had reached a point of profitability. Although participants claimed smaller farms were more nimble than larger farms, and able to respond more quickly to market signals and trends, some crops complicated such abilities, regardless of scale of production. Raspberries, for instance, require a significant initial investment in preparing the land to ensure proper drainage, and planting the actual plants. Depending on the variety, however, the new plantings may not produce substantial crops for several years (Demchak, Harper, & Kime, 2005). The Northern Puget Sound region is ideal for berry production, and such place-based factors influence the range of possible adaptations. However, planting berries is not an immediate means of adapting to market signals.

Modifying an operation's production regime so extensively might require taking on more debt. One participant said:

> I don't think any farm or any business can be resilient under a severe stress of debt because the bankers don't care. They just want their money.

Additional debt and the time required for the adaptation to become profitable reduce the farmer's flexibility in the short term. Another participant stated succinctly, "you're only as good as your banker."

The second major threat occurring at the farm scale is the dependence on inputs not available on the farm itself or influenced by factors and events occurring at larger scales. Participants felt they had less control over access to these inputs and saw the potential for disruption as a threat to their farm's persistence. On a modern farm, operators depend on the timely shipment of inputs. To varying degrees, and depending on the product, a modern farm needs steady supplies of fuel, electricity, water, feed,

fertilizer, pesticides, herbicides, and information. Many operations also need perishables, such as milk, transported to markets or a processing facility in a scheduled, timely manner. Disruption of these cycles of delivery and transportation have the potential for increased spoilage and lost time and opportunity, as well as the potential for upsetting the ecologic rhythms of farm crops and animals. Participants raising animals, especially dairy producers, saw these dependencies as a particularly serious threat since they rely on the steady rhythm of shipments of feed into and milk from the farm. These shipments also rely heavily on an adequate transportation infrastructure. Disruption of these rhythms could have serious consequences to the operation depending on the length of disruption. In relation to this threat, participants found the flooding scenario, with its potential in disrupting transportation infrastructure particularly threatening.

Participants producing livestock and dairy products also noted the importance of a steady source of another input: water. One participant stressed maintaining access to water for his or her livestock:

> I think [water] reliability is an enormous issue. When you are talking livestock, you can short them on feed it's no big deal, you just feed them and they are happy. You short them on water and they are stressed for a month. They will get more water than they need to just because they are insecure about it.

Dependence on inputs originating off the farm and controlled by higher scale processes represents a loss of control over aspects that potentially drive decisions at the farm scale. Such loss of control is exacerbated by extreme events. Flooding potentially disrupts input deliveries and product transportation away from farms, while increased

interannual variability in precipitation has the potential to disrupt reliable and regular access to water.

Participants noted that the lack of time a farmer has to dedicate to the different aspects of his or her operations also constituted a threat to a farm's persistence. This theme emerged through discussion of farmers needing time to experiment with different production methods or the amount of time needed to adequately develop a skill set. One farmer in San Juan County suggested farmers could switch from diesel-fueled tractors to draft horses to reduce off-farm inputs. Another participant replied:

> I think the biggest hang-up to me is that it takes time and energy. You just don't have it on top of what you are already doing. You know, the draft horse thing it's a great idea, but it's a whole 'nother career to draft animals and use them.

Continuing, he stressed the need for continuity in the passing down of such knowledge between generations:

> And that kind of goes back to that area of knowledge. Not only is it another career but we don't have the knowledge base that brings that forward to us. I mean, you know, . . . has been working for 20 years to capture that knowledge. We don't have a grandfather or an uncle to bring us there safely.

Other aspects of this theme related to the lack of an off-season (especially dairy and beef farmers) limiting time to experiment in between seasons, the lack of time needed to advocate on their own behalf, and time spent on regulation compliance takes time away from farm management (discussed at the food system scale).

The threat to a farm's persistence caused by the lack of certainty in farm ownership and succession was a threat that arose consistently in all three counties.

Participants saw the lack of children wishing to take over their operations as a threat to whether or not their farm could survive. One participant put it thus:

> One symptom of the lack of viability is that children of most of the farm families in the county do not stay in farming.

While participants noted that some of today's youth are interested in farming, general interest in the occupation is declining. Furthermore, several participants lamented the fact that many of the youths now interested in farming were more idealistic than practical, with little to no knowledge of the skills and processes that keep a farm functioning. Lacking interest, there exists greater chance of the loss of farming knowledge and the culture that reproduces that knowledge (see Hassanein, 1999), thus threatening the persistence of individual farms (in the case of family succession) as well as a region's farming heritage (in the case of general lack of interest and changing land use). Other participants agreed that the lack of younger farmers to take over farm operations was a concern, though they argued that lack of interest was directly related to the lack of stable profits within the sector. One participant, active on his father's dairy operation, expressed doubt as to whether or not he was interested in taking it over:

> I don't know if I am going to be a farmer when my dad decides to retire, because I don't know if I want to deal with all of it and I don't know if I could even buy in and buy all his property. I don't think I can afford to take over my dad's dairy if it's not profitable.

Farming as an occupation, participants felt, has to be financially enticing enough to attract and retain entrepreneurial talent. Without being motivated by somewhat certain profits in the farming sector, participants saw the decision of farm-raised youth to pursue 9:00 – 5:00 jobs with larger paychecks, benefits, and paid vacations as justified.

Participants noted the financial difficulties for farm-raised youths choosing to take over the family operations. Those who do make a lifestyle choice, still face high costs of buying out their parents making a transition from one generation to the next difficult. One participant stated:

> If people want to transfer a farm from one generation to the next it has to be profitable to do so and I see these land prices that were up so high and they have come down quite a bit since then, that could be a difficult thing to transfer over to the next generation because in order to service that much debt there has to be profit involved.

The high value of the land, equipment, and buildings thus serves as a barrier to transition. Waiting until the death of a parent could further compound difficulties by adding estate taxes into the cost of acquisition. One participant stated with morbid humor:

> We're hoping he dies this year, we told him there's no estate tax this year so we told him you know, we love you but if you are thinking about anything this year would be the year. Next year don't even bother! You might have to stay around!

4.1.3 Thresholds

Participants noted potential points at which a system crossed a threshold where a shift would occur in the identity of the system. At the farm level, one such shift frequently occurs following the death (5 coded instances) of the primary operator of a farm with no person readily available to take over the operations. Such an event could result in the loss of the land to developmental pressures or neighboring farms buying up the land and infrastructure and incorporating it into their operations.

Some participants claimed that at some point the best use of the ground might no longer be in agricultural uses (2 coded instances). This relates to some of the threats

faced at the farm level such as the degradation of soil fertility to a point where the land becomes marginal enough that potential future farmers might no longer be willing to invest in the land, due to a perceived low rate of return. The land then transitions to another use. While there were only two coded instances, the idea that a piece of land's best value might no longer be in agricultural use may be more widely believed than this analysis suggests. Another farmer, referring to his tax burden, profit margin, and possibilities of finding a willing buyer for his farm, affirmed this idea, saying "there's a point where you just say what's the point. It's not worth it."

4.1.4 Adaptive Strategies

At the individual farm scale, participants identified several strategies and resources that might assist in adapting to threats and changing circumstances. In this subsection, I begin to answer my second research question in relation to the farm scale. Participant suggestions were wide ranging and addressed different aspects of their own operations or responded to threats another farmer faced for which one participant may have already found a workable solution. Such strategies and resources for adaptation fell under economic (34 coded instances), planning (10 coded instances), personality (44 coded instances), skill-set (17 coded instances), and technical (24 coded instances) themes.

Participants discussed strategies and resources that might allow them to better handle some of the economic threats they face, such as the tendency to carry a high debt-load. Adaptation suggestions included lowering costs and dependencies on goods and services acquired off-farm. Participants discussed adapting operations to lower

capital needs and carrying lower amounts of debt. One way of doing this, participants mentioned, is to cut costs by reducing energy usage and promoting efficiency in input use. Another way, participants said, was to change the marketing style of the farm. By switching over to direct marketing, a farmer would have greater control over the amount of money that would go into the farmer's pocket. Along similar lines, participants noted, was the need to find a market niche where the farmer would be more able to set the price him or herself and not worry so much about competition.

Some participants discussed cutting costs through better farm management. Largely in this case, participant comments focused on technologic improvements towards more efficient irrigation practices, the ability to extend the growing season, and backup generator systems run by computers. Participants recognized the up-front investment costs in adopting such technological improvements, though they believed that, in the long run, the more efficient and reliable use of resources was worth the initial investment.

Participants also saw the ability to plan, budget, and act, through stable and reliable relationships and through access to timely information, as necessary to enhancing small farm resilience and adaptability. Thus, the overarching adaptive strategy of strengthening an individual farm or farmer's ability to develop a plan for both short and long-term eventualities involves increasing farmers' access to critical information in a manner timely enough for farmers to act.

In discussing their ability to plan over the long term, participants saw the stability created by one person, either the farmer or a long-term landlord, owning farmland as being necessary to plan longer-term strategies in farm development and

land use. Without clear and stable ownership, participants noted that a farmer would be less willing to adopt strategies over the long-term. Such reluctance in employing potential long-term adaptive strategies limits the range of options available to the farmer, thus limiting his or her ability to adapt. Additionally, depending on the unique circumstances each farm operation presents, long-term adaptation strategies may be more pertinent.

Participants most often discussed personal attributes of the farmer as adaptive strategies at the farm level. Participants described farmers as either having the personal attributes required for successful farm management or not having them. Thus, adaptability and resilience, in participants' minds, consisted substantially of the farmer's personal tenacity and "hopeless optimism," more than specific strategies of input and debt reduction or diversifying production.

When pressed on how they keep going in the face of adversity, answers frequently highlighted some personal characteristic. The answers most valuable to this research related to farmer knowledge and experience. Several participants noted the importance of the multiple skill sets a small farmer needs to succeed. Running a farm requires a knowledge of and attention to weather cycles and patterns to ensure optimal planting, fertilizing, and harvesting times. Weed and pest pressures must be kept under control at critical stages of crop production. Farm implements and machinery need maintenance and repairs. The business side of the operations requires financial savvy and managerial acumen to keep abreast of environmental, tax, and labor regulations while maintaining profitability. And increasingly, farmers stated that they must have the social ability to navigate a world of neighbor relationships and media attention,

where farming practices are increasingly becoming politicized. Such skill sets take time and experience to develop, a mindset open to continual learning and creativity, and a fair amount of luck. The smaller the farm is in terms of gross sales, the more the primary operator must handle such tasks. Although, many of these characteristics can be learned or influenced by educational programs, participants continually highlighted that it is the passion for the occupation that is most important to their continued self-education and thus resilience in the face of disturbance.

Several participants suggested technical strategies of adaptation. Such strategies largely focused upon increasing efficiency in resource usage or mitigating external threats through the application or development of an engineered project. Many participants discussed, for example, their use of generators to buffer power outages during flood events. One participant referred to the sophisticated automated backup system run by his computer as his insurance policy, while others discussed the need to maintain reserve fuel to keep their operations running in the case of a power outage.

Other technical adaptive strategies that participants suggested were dredging flood prone rivers and developing alternative energy production. Whether or not dredging the rivers would actually reduce the recurrence and severity of flooding, participants felt strongly such a strategy provided benefit to the general public through decreased recurrence of flooding events, as well as the agricultural sector. Decentralized alternative energy development for the agricultural sector was unquestioningly suggested for long-term adaption. However, despite the perceived obviousness of energy independence, participants agreed that initial costs are a significant barrier.

4.2 Community Scale

In this section, I report on and discuss the themes that emerged at the community scale (Table 6). A clear pattern of networks and connection between people and agricultural infrastructure emerged from the transcripts at this scale. The strongest discussion focused on the infrastructure needed to sustain viable agricultural operations and threats posed by the loss of such infrastructure in the short-term (e.g., impassable roads due to flooding) and the long-term (e.g., closure of a processing facility on which area farmers rely).

Scale	System	-	Threat	-	Threshold	-	Adaptive Strategy	-
	Infrastructure	19	Social Infrastructure	37	Loss of Infrastructure	15	Network	27
	People	13	Physical Infrastructure	36			Community	24
Community Scale	Relationships	12					Relationships	13
							Social Infrastructure	5
							Physical Infrastructure	4

Table 6: Community scale theme frequencies.

4.2.1 System

Farms and the people who operate them exist within communities. Participants discussed such communities as composed of infrastructure (19 coded instances), people, (13 coded instances), and relationships (12 coded instances). The system identities at this scale are just as problematic in generalizing as are individual farm identities. One participant discussed the islands of San Juan County as a series of different communities, each with its own population center and unique culture. From such a perspective, each county consists of multiple communities, in turn each

community potentially consisting of multiple farms as well as the non-farm population. Other participants described the term community as sharing common values, such as the rural qualities that drew residents to a particular location in the first place. Yet other participants discussed communities in terms of organizations, such as the Agricultural Resources Committee in San Juan County, and Sustainable Connections and Whatcom Farm Friends in Whatcom County that provide advocacy and education. These different communities in the region possess physical infrastructure, as in the case of meat and dairy cooperatives, and political infrastructure (in terms of lobbying), as in the cases of the Agricultural Resources Committee in San Juan County, and Farm Friends in Whatcom County. Such infrastructure helps shape the identities of different communities.

4.2.2 Threats

At the meso, community level, participants discussed threats to small-scale agriculture in terms of degradation of physical (36 coded instances) and social infrastructure (37 coded instances). In their view, adequate infrastructure was a necessary prerequisite for a thriving agricultural sector, and its degradation or loss, whether sudden or gradual, constituted a threat. In describing such infrastructure, participants did not limit themselves to the transportation and energy systems that normally come to mind—although transportation and energy came up again and again and were stressed as fundamentally critical in the long-term survival of agriculture. Rather, participants discussed infrastructure as networks through which tangible and intangible objects could travel. This included physical infrastructure such as roads, rail

lines, processing facilities, and farmland, as well as social infrastructure, including networks of family and friends to lend assistance in times of crisis.

Specifically, threats constituted events or processes that endangered or disrupted the smooth functioning of such infrastructure networks. Each of these threats, noted by participants, concerns the relationship a farmer establishes with the community around him or her. These relationships serve as the social infrastructure that enables the farmer to function more easily by providing capital or services otherwise unavailable.

One threat at this scale noted by workshop participants was the turnover of people in the community. A high rate of turnover presented several difficulties to farmers. Short-time residents are viewed as being less vested in the community, having less understanding of the issues facing the community, and having less established relationships with other members of the community. Explaining the difficulties in rapid population turnover, one participant stated:

> You've got this constant turnover of people that aren't vested here. I mean they may be in terms of the scenery, but it takes them a while to get a sense of what is potentially happening.

Population turnover affects the relationships between landowners and farmers that lease. One farmer noted the variability in who owns the land and the necessary interactions between farmers and landowners as a concern:

> But that actually reminds me of the discussion I was having at the other table about urbanization and with a large influx of people the vulnerability was about the constant change over of who they were having to interact with and land owners, who they were leasing from and that variability was very scary.

In agreement, another participant noted that the ideal notions a new landowner came in with could present difficulties in the landowner and farmer relationship:

> The kind of place that it is marketed to be to incoming land owners and so forth is as this sort of paradise Shangri-La existence and I think that really complicates the land leasing.

The realities of a modern agricultural operation, with the accompanying smells, noise, and long-day schedules can differ significantly from what newcomers might find desirable in neighbors. In an effort to protect farmers against complaints stemming from such characteristics, many counties have adopted "right-to-farm" ordinances, prohibiting farms from being considered nuisances or disturbing the peace.

Also of concern to participants were the relationships between farmers and inspectors tasked with ensuring compliance with food safety regulations. Participants thought that inspectors who have a relationship with the farming community might have more understanding in performing their duties. Such understanding might result in collaboration in addressing concerns as they arise rather than fueling antagonism and miscommunication. As one participant said:

> . . . the trend is for regulations to become tougher, and tougher and tougher in terms of protecting larger and larger populations but the insensitivity is that those regulations which are then set at a national level get applied to a small farmer level where they becoming increasingly dissident. We've got this in a very local situation in this county where we got a new food inspector who comes in a few years ago and completely disrupts a whole bunch of people.

Related to the community of farmers and existing relationships, one major concern was the attrition of support services and agricultural infrastructure. One participant noted:

> There is sort of a critical mass of a number of farmers that gives you an infrastructure. Somebody who can repair tractors and a place to get your fertilizer that's not hundreds of miles away and right now I feel very tied to the Skagit Valley and the success of farmers there to be able to access easily the materials and expertise and equipment and I am grateful it's there because it's only 20 miles away but I feel vulnerable to that.

Similarly, a representative of a cooperative noted the reliance on two skilled positions:

> If something happened to our butchers, there's two, one of him cut his hand and was out for what, quite a while, then we were down to one and if something happens to him it's not like you have another one lined up ready to do that job.

Similarly, diversified market gardens that rely on the physical space of a farmers' market each week to sell their goods are vulnerable to the loss of this critical market infrastructure: "It's like, if the farmer's markets folds, what do I do now?" Thus, the social and economic infrastructures form a critical web on which farm operators rely to carry out their day-to-day operations.

4.2.3 Thresholds

At the community scale, participants saw events in which infrastructure critical to the sector was lost (15 coded instances) as potential thresholds to irreversible change. One such example that was cited by several participants in different circumstances was the closure of vegetable canneries, particularly pea canneries, in Western Washington. The loss of a necessary processing facility in the region signified a point in time beyond which growers would no longer be able to function as they had in the past. The loss of a processing facility is a clear event in which participants were able to discuss concretely as passing a threshold where the agricultural sector qualitatively changed.

Other examples of infrastructure loss that participants discussed were less concrete in terms of a point in time beyond which farming is no longer possible. The Snohomish County workshop, particularly, offered discussion on the gradual loss of support services as making individual farm survival gradually more difficult. The increased cost and time involved in traveling to the next closest company or individual that offered the service merely increased pressures on the farmer. One participant noted the need for a diversity of operation sizes to retain the needed services:

> . . . without the big farms they won't have the infrastructure, they are not going to keep an equipment dealership going or a seed company, without the big farms to keep those guys around to provide the services to the little guys also.

Another participant noted services wouldn't likely disappear entirely; rather, the increased costs would present the threat to smaller producers:

> You'll still be able to get it, but it's not going to be at the cheap cost of the guys that are buying bulk for the big guys that can sell it to everybody. They are going to have to go to Oregon. Just like now, the organic farms they got to go to Oregon to get their fertilizers and stuff because there is no big organic guys up here that are going to draw those business up here to sell organic products like fertilizers and sprays and whatever else. It's all down in Oregon and so it costs these guys up here a lot more and that's how it will be for conventional little backyard farmers or whatever you want to call it if all the big guys are gone.

Participants did not specify at what point a threshold was crossed in this process, however. Similarly, participants discussed the gradual attrition of a certain type of farmer until that part of the sector disappeared.

Another threshold noted by participants combines the farm and community scales. At the micro level, when a piece of land passes from one owner to another it crosses a threshold in individual ownership. This in turn, affects the existing

relationships at the community scale. For example, one participant discussed the transition of a piece of land he previously used with permission from the previous landowner:

> You know, I have had a lot of people come to me and say, well how do I educate this new landowner on this 20 acres that I have taken hay off of and run animals on for the last ten years. You know, they are not interested in the things that we do and so the big challenge as I see it is all the people that are in those relationships have to revitalize that communication with those landowners and as more and more of it have it.

Such a transition might constitute a threshold for only the unit of property whose ownership changed hands, which influences the community; or, such a transition could push the community across a threshold of the necessary support for agricultural activity.

4.2.4 Adaptive Strategies

In the context of these threats, participants discussed strategies to promote resilience at the community level as strengthening existing communities (24 coded instances) and networks (27 coded instances), while working to foster additional relationships (13 coded instances) among producers and between producers and the non-producing community. Participants devoted significant discussion to strategies implemented at the community or neighborhood level. Some examples include localized, decentralized energy production, and concentrating on producing for nearby consumers. Broadly speaking, participants' ideas of strategies at the community level dealt with networks, the relationships between the different nodes in these networks, and the community resulting from these first two ideas.

I use the concept of nodes to assist in this analysis. I use the word to describe both people and the physical points in infrastructure networks. Workshop participants spoke of the strengthening of relationships between such nodes through a variety of means. One participant specifically spoke of resilience in terms of community linkages and interdependencies:

> I was thinking about the image that you've heard before sort of the spider web where you have linkages between growers and suppliers and people that are having the byproduct that could be used for other people and that the stronger the web you are weaving the more resilient the community is going to be and maybe we could put it on the resilience factor, strength of linkages, interdependency.

This idea of one actor in a network complementing another arose in different circumstances, particularly among participants from the San Juan Islands. A participant from San Juan County described his experience in collaborating on logistics with a freight shipper in the islands. The shipper focused on bringing goods to the islands, while the farmer focused on getting farm products off the islands. The two were able to collaborate and complement each other's operations to reduce costs and increase efficiency:

> So they go off island with empty trucks, we need to get our stuff off island so we went to them and say why don't we use your empty truck going down instead of you going down in an empty truck. We got our stuff off in a collaborative thing then. It's his interest to get something and we get it much cheaper than shipping by regular and it fills out his time more. So that's another one of these examples that I was talking about earlier. The complementary nature, if you look at what we've got as a mini society, instead of trying to organize the world we can organize the county by these collaborative and these interactive processes which also has the side benefit of insulating you to some degree from, as I said, these external forces.

Another participant echoed the sentiment:

> But you need to start involving the farmers with the business and everybody needs to start understanding that this is all part of the cycle and it is complementary.

When discussing the scenarios dealing with rapid onset hazards (flooding in particular), participants noted the ad hoc groups of neighbors, friends, and family that would lend assistance at short notice. This was discussed primarily among dairy farmers and cattle growers in getting their herds to higher ground before the floodwaters arrived. In Whatcom County, where several farmers keep cattle in the flood plain, participants discussed this topic at length. Quick herd evacuations was not as relevant a topic in San Juan County, where flooding was not an issue due to island topography and the lack of major rivers with floodplains.

4.3 Food System Scale

In this section, I report on and discuss themes emerging at the food system scale (Table 7).

Scale	System	_	Threat	_	Threshold	_	Adaptive Strategy	
	Government Policies	21	Regulations	56	*Vague*		Support	28
Food System Scale	Economic	16	Uncertainty	30			Public Education	17
	Public Ethos	15	Paradigmatic	30			Interns / Next Generation	7
	Climate	7						

Table 7: Food system scale theme frequencies.

The strongest discussion centered on the influence exerted on the food system by government and the general public's understanding of agricultural issues. Of the three scales discussed by participants, the food system scale was the least concrete, at times vague as to what constituted threats and thresholds. However, this scale was also the most contentious, especially in Whatcom County, as participants argued over the merits of different production methods and various regimes of government support.

4.3.1 System

Clearly, the farms and the communities of farms, infrastructure, and the non-farming public all exist within the context of larger, macro scale processes and events. Participants displayed a keen sense of being situated within a larger socio-ecological system, speaking of this larger system in terms of the public ethos, economics, climate, and government policies concerning the food and farming system. Despite this knowledge of the existence of a larger socio-ecological system around them, participants conveyed a sense that the general public, including themselves, did not understand its behavior. Such acknowledgement of the lack of complete understanding did not prevent participants from arguing over system behavior or advancing hypotheses as to the system behavior's effects on producers.

Participants gave considerable discussion to what they called "the food system," of which they considered themselves a part. This larger socio-ecological system is comprised of the climatic and environmental conditions (7 coded instances) that food production relies upon, the legal framework through which production is regulated (21

coded instances), the economic system that assigns value to products (16 coded instances), the environment in which they are produced, ways to regulate or exploit the environment, and the public discursive ethos (15 coded instances) that influences all themes already mentioned. Such delineation of a larger food system is not new. Over the past decade, several popular books and films have discussed issues at this scale through a variety of means (Kenner, 2008; Pollan, 2006; Schlosser, 2001). Many workshop participants echoed the popular critical stances, speaking of the larger socio-ecological food system as presently concerned with treating food as an economic commodity indistinct from cars, sweaters, or electronics in production and trade.

Participants understood food production as a landscape-shaping process situated within the larger socio-ecological system. However they felt that the general public's valuation of agricultural landscapes is disconnected from the economic processes that both shape and threaten it. One participant stated that the majority of the consuming public did not support local producers:

> They do not get the relationship between living with the landscape and supporting the landscape.

This interactive relationship between the consuming public and the landscape can function reciprocally, though the sense over the course of the workshops was that changing the nature of the relationship is a difficult task.

Part of this paradigmatic movement that has started to change the landscape of the agricultural system is the relatively recent consumer desire for foods produced organically, locally, or both, particularly among young urbanites. One participant put it simply:

> I think there's a certain sexiness about Seattle buying products from the San Juan's and they are all about that.

Another participant, also from the San Juan Islands, stated:

> We have all benefited in the last five years by emotional people willing to pay more for organic foods.

Through this notion of the attractive rural qualities having a positive effect on local producers' markets also negatively affected local producers. One participant stated:

> People are coming here because they value the rural qualities but it seems like there is often a disconnect between valuing it and then understanding what it takes to keep it that way and why it is there and how to preserve the farm land.

Participants saw such ideas held in the public's mind as active drivers on the socio-ecological system. As the above quotes illustrate, the changing public valuation of certain landscapes may lead consumers to purchase more "local" foods, though such valuation may also influence greater numbers of people to seek out "rural living" experiences first hand, thus potentially increasing population pressures on rural areas and causing farmers to conform and modify their practices.

While rural images and food discourses play driving roles in the macro level socio-ecological system, participants saw bottom-line money and profitability as the major drivers of the larger system. While they know from experience that environmental conditions played a major role in crop production, market economics and regulatory frameworks also influence the farmers' choice of which environmentally-possible crops to produce. The larger forces of public discourse and ethos in turn influence the economics and regulatory frameworks. One resulting

cultural force of these interactions is consumer choice and consumer desire. Consumer desire for cheap products plays an influential role determining system processes:

> People want cheap food and right now we are importing more than we grow and nobody is complaining. Nobody cares.

Another participant agreed:

> I don't think anybody knows, but even if they did know, we import cars, we import food, what the heck.

Although these comments that "everybody bases their food decisions on price alone" contradict other participant comments as to the appeal of local, organic food, they do highlight participant perception that small, local production is still only a niche market aimed at relatively affluent customers.

However, the profit motive was not always referred to in negative terms. At a certain point, participants conjectured that processes some might view as negative will reverse or be changed by the lack of profitability in previous operating schemes. An example given by one participant referred to inefficient energy usage habits changing due to rising energy costs:

> If . . . power gets so expensive people are going to seek out alternatives. Then, you won't even need incentives . . . The dollar is the ultimate motivator for change.

In such a scenario, the system corrects itself. This view at first seems to be inconsistent with other participants' views. But we should view these slight contradictions as indicative of the complexity of different driving forces that shape the cultural, environmental, and economic landscape that affects the agricultural sector, as

well as the difficulties farmers had describing and understanding the larger socio-ecological food system.

In contrast to the public ethos and economic aspects of the macro level system, participants discussed climate in fatalistic terms. Climate was viewed as one of the central challenges of farming, a factor that had to be dealt with and responded to every day. One participant summed it up:

> The wind, the water, the temperatures. We are vulnerable to all that stuff. So we are constantly vulnerable to climate. We live and work in the climate, that's just the way it is.

Participants contested each other's memories of the extent the local climate has changed over their lives. Some discussed the changes they have seen over their lifetimes, while others sharply contested their views:

> Participant A: I'm thinking just in my lifetime how much it's changed here in Whatcom County as far as weather goes.
>
> Participant B: Really, my dad says it's exactly the same.
>
> Participant A: I disagree, because I remember playing, we've had property here since I was 6 years old out in Ferndale, and I remember times when I would come up here and be stuck after a snow storm because we came to visit relatives . . .

Although participants did not agree as to if and how climatic patterns had changed over their lifetimes, all spoke of climate as highly influential in the decisions made in their operations and would remain so into the future, regardless of how it changes. Participants expressed these views as if they were obvious.

Participants noted that events and processes at the food system scale had significant influence over the way they ran their operations. Policy enacted at the

national and state levels had a direct effect on their management decisions. One participant noted:

> So, in terms of what's happening in our little world, what happens in Olympia is really a big . . . deal.

The statement was not contested, nor did any participants discount the importance of events and processes happening at higher levels of government. Another comment noted the power of definitions at the policy level have over what happens at lower scales:

> So whatever that little definition is that somebody in Olympia or wherever has figured out once it gets applied out here then it has all these ramifications.

The effect of government policy came up in conversation often, usually in negative terms. Many participants noted the "good intentions" of policy, but that "a lot of policies have unintended consequences." Government creates regulations with certain goals. One participant said it in these terms:

> As the world gets bigger and the population of the food demand becomes greater and any of a number of different factors you end up with, the trend is for regulations to become tougher, and tougher and tougher in terms of protection larger and larger populations.

As such, government policy and the ensuing regulations were a cost to be dealt with. One farmer approached this subject as fatalistically as many participants did climatic threats:

> Regulation is just a piece of the challenge of farming. Labor is a major piece of the challenge of farming, the cost of resources, whether it be land or equipment, is a piece of the challenge of farming.

He went on:

> You have these different challenges or modules that you deal with, we are pretty good at deciding do I want to buy that tractor or that tractor or that truck, because we can look at that hard asset and make those decisions of will it fulfill the needs that we need.

To summarize participants' discussion of the macro socio-ecological system: farmers are situated within a larger socio-ecological system that is driven by an economic bottom line, the general public's desire and valuation of the landscape, climatic patterns, and the consequences of particular polices at larger scales of government. Participants spoke of themselves, their operations, and similarly situated operations as being situated within this larger system. The complex and sometimes contradictory forces interact in nuanced ways that participants thought the general public as well as themselves had difficulty understanding. Such complex interactions invariably influenced how the participants managed their operations and tried to adapt to environmental, economic, and social trends.

4.3.2 Threats

Within this larger system, the uncertainties and misunderstandings discussed above put farmers on the defensive. This is especially so with respect to the increasingly complex regulatory framework they have to operate within:

> There is just so much that it is very difficult for the individual farmer if he really wants to follow all the rules and regulations to get out of bed and do anything in the morning. I would guess that in coming here today I must have violated something or other somewhere.

While this last statement was likely intended humorously, the participant seemed less certain of his or her place within the larger system's growing complexity. Comments suggested that farming now is not like it was in the past. Regardless of the degree or

lack of change, such comments reflect an increasing uncertainty in the individual's place or ability to thrive within the larger system.

Adding to the uncertainty of what the rules of the game are, some participants discussed the possible satellite surveillance ability for government and regulatory agencies to monitor farmers' land use:

> They can see what changes people have done to their property and they can send out code violation notices; they happen, the program I was listening to was making a point of saying that's illegal and I don't know if it is or not.

Not all participants discussed surveillance as a perceived threat; however the sentiment of what aspects of production will fall under a regulatory focus and how such regulations will affect existing production was a common one. Speaking to the unknowns in agriculture, one participant stated:

> I think there's a lot of unknowns and I think government regulation is probably one of the bigger unknowns that you could not know what's going to hit you and to adapt to those or you can't adapt to them. Those are some things, fish habitat, streams and setback, and water rights. Those are all things you don't know what's going to happen to you until you come in and obtain permits.

Participants expressed threats of three general kinds at the macro level: uncertainty (30 coded instances), regulation (56 coded instances), and paradigmatic threats (30 coded instances). The lack of understanding and ability to predict future climatic patterns, government action, economic trends, and the public's food desires was woven through the conversations of most of the participants across the three study area counties.

Participants' discussion frequently focused on themes involving the lack of certainty as a threat. This was especially true at the macro scale, where processes are

complex and not necessarily visible on a day-to-day basis. One participant expressed it thus:

> Well, I've been in the system for 37 years and I still don't understand how certain class prices are set.

Tangential to these uncertainties was the perception of regulatory and paradigmatic threats. While some participants saw regulation as originating from good intentions, and some saw government regulation as inherently evil, several major concerns were raised concerning them.

Regulatory restriction was primarily viewed as stifling the flexibility and creativity needed to effectively run an agricultural operation. A major factor behind this stifling, participants said, was the disconnect between those who craft the rules, regulations, and policy, and those on the ground who have to work around the limitations imposed on them. One example given is the redundancy in paperwork, certifications, and inspections between agencies. Washington State's DOE may require a similar inspection as the Federal EPA, though two different inspections are needed to satisfy both agencies on basically the same grounds:

> I make apple cider and so I get, Whatcom County wants to inspect me because I sell retail off of my place. WSDA wants to inspect me because I sell some of it to the green barn and USDA wants to inspect me because I sell some of it to the green barn and not all of it off my farm. So I got three agencies asking the same questions, looking at the same process, with three sets of regulations. They are not all the same. You can satisfy the state but that doesn't satisfy the county, you can satisfy the county and state and you still haven't satisfied the USDA. For instance and just because you come into compliance with one of them you are not necessarily in compliance with the other one.

Another participant noted difficulties presented to farmers in passing on the farm to the next generation such as estate and inheritance taxes. Because of the lack of cash flow, inheritors have to sell part or all of the operation to finance the taxes owed.

Lastly, participants discussed at length the general public's desire for cheap food, general apathy about food origin, nutrition ignorance, and naïve and bucolic notions of the realities of agriculture. These concerns were of a more paradigmatic nature, swayed by education and economics.

4.3.3 Thresholds

While participants discussed thresholds at the food system scale, the discussion did not identify concrete points of unavoidable transition. Given the vague and sometimes contradicting notions of what constitutes participants' idea of the food system scale, it is not surprising that participants did not distinguish concrete points in time as points of transition to a different system state.

4.3.4 Adaptive Strategies

In terms of tools and strategies to be applied to these concerns and threats at the macro level, participants largely spoke in terms of government programs (28 coded instances) taking a facilitative role in helping farmers help themselves. Such views focused less on present government programs of price supports and disaster insurance and more on funding infrastructure improvements, internship programs (7 coded instances), and public education (17 coded instances). However, the participants' views as to what tools and resources can be implemented at the macro level predominantly

remained within the frame of government support. Departing somewhat from the frame of government support is the idea that public education serves as a tool to increase the small-scale farmers' ability to adapt to changing economic, environmental, and cultural conditions in the future. Here, I discuss participant views on government support and public education as means of fostering adaptive capacity in small-scale producers.

Participants discussed government support as a means of enhancing small farm resilience at the food system level. Support included shifting subsidies in greater favor of smaller producers. As one participant said:

> Maybe the time has come to shift some of that subsidy over to small farms and there are a lot of things that could be done to help sustain the ones that exist and even encourage further development over time from grants for infrastructure improvements, subsidies for internships for educational opportunities of the next generation of farmers, housing for interns and farm workers, tax credits that would make it more attractive for people to keep their farms in farming or for people who are not currently farming on farmable land to lease it out to people who would farm it, so a whole set of incentives are possible to help encourage small farms and being able to survive.

This response covered much of the range of ideas generated by participants. In this view, subsidies would be a tool to maintain current small producers and encourage future small farms through physical infrastructure and the social infrastructure of enabling knowledge to be passed from one generation to the next through internship and educational programs. Otherwise, farming was not an industry seen as encouraging entry and entrepreneurship.

One participant suggested subsidies go towards nutrition programs, where emphasis would be placed on quality over quantity:

> I think a more useful place to direct subsidies would be to nutrition programs, to subsidize consumption of high quality foods and help poorer people deal with the inevitably rising costs of food.

Another participant suggested increasing food stamp flexibility:

> Right now, if somebody is on food stamps they have their choice of how they want to spend their food stamp money . . . that's farm subsidy money basically. So why not expand and improve that system and let the folks who are purchasing those things worry about whether they want soybeans or grass-fed meat from Jones family farm.

The suggestion is similar to that concerning nutrition above. The assumption is that when affordable to do so, consumers will buy higher quality produce and foods rather than what these farmers saw as industrial foods.

Participants also noted the need for a greater effort in educating the next generation of farmers and being able to get them on the land. Government support to decrease the need to sell all or part of the farm to finance a retirement would assist in the transition:

> We need a bridge to get the young people on our farms so that they can come, they have got money from the state to get us off to go live in that condo we want or wherever we want to do, or stay on the farm if we want to help them.

However, participants discussed public education about the realities facing the agricultural sector as being a key strategy in promoting the resilience of smaller scale producers. In this respect, the ethos and will of the general public plays a large role in shaping the system and steering its evolution. As discussed above, participants recognized this as a significant force. Influencing the direction of such a force would then play a major role in participants shaping a system they felt was supportive of increasing their adaptive capacity.

One participant stated the need to push education in order to bring about the change they desired:

> There needs to be more advocacy from the standpoint of education, consumer education.

Participants frequently discussed educating the consumer as to the realities farmers face as producers as a major step forward toward enhancing the image of food produced here in what participants felt was a fair and realistic manner:

> Well then the first shift has got to be that we have a public system where they honor food grown in the United States and they say we will feed our people here in the United States.

Such food "patriotism" was assumed to help smaller local producers compete with the larger scale producers on the international market. Many participants assumed that agricultural products from the United States are superior and that if informed the general public would think so, too:

> I wish they would do those country of origin stickers because that I think consumer choices would just change if people actually saw where their food was coming from.

As such, a strategy of educating the consumer in what is available would lend assistance to more local producers.

Chapter 5: Conclusion

In this section, I reflect on the results reported on and discussed in chapter 4 and how these findings fit into the literature on resilience and vulnerability in agriculture, as well as the larger ecological and disaster resilience literatures. I discuss the contributions this study makes to the fields of agricultural and disaster research by noting which concepts in the literatures are advanced through this research, as well as which concepts are questioned. Here I pay particular attention to the concept of stability in the resilience literature and the way in which themes of stability wove through participant conceptualizations of resilience and adaptation within different scales of the socio-ecological system. I finish the chapter by discussing future avenues of research and possible limitations.

This thesis, and the larger research project of which it is a part, seek to engage and encourage discussion as to what constitutes resilience in the agricultural sector and whether or not resilience helps explain how researchers and farmers understand the means of adaptation and success despite frequent and multifarious adversity. This thesis also discusses how farmers situate themselves within the larger socio-ecological system in which they are embedded and notes how farmers in Western Washington seek to enhance their resilience and adapt to changing conditions. This discussion, then, is an attempt to begin to fill the gap in the literature concerning resilience in Western Washington State agriculture by documenting farmers' imagined adaptive strategies and their perceptions of the vulnerabilities of their operations and the agricultural sector in general. The disaster-planning workshops from which this thesis derives its data are a critical first step in bringing "resilience thinking" (Walker & Salt, 2006) into

ongoing conversation between farmers, academics, and the other agricultural sector stakeholders that reviewed and contributed to the development of the scenarios. Such conversations between practitioners, stakeholders, and academia are necessary in knowledge development (Baars, 2010) and in the equitable, flexible, and creative management of natural resources (Olsson, et al., 2004).

5.1 Perceptions of Vulnerability and Adaptation

From the themes that emerged through the transcripts, it is clear that farmers in San Juan, Snohomish, and Whatcom Counties perceive a number of threats to farming associated with the hazards of flooding, urbanization, rapid increases in energy costs, and climate change and that these threats differ according to scale. It is also clear that farmers in Northwest Washington see themselves within a larger socio-ecological system, much of which they see as beyond their direct control of influencing. Clearly, participants felt that government policies and regulations did not enhance the agricultural system in which they are situated. In all three counties, several participants mentioned that agricultural policy, at the state and especially the national level, favors large-scale producers, while regulations harm small-scale producers who might not have the means to maintain compliance while remaining economically viable. The favoring of larger producers thus impeded the ability of smaller producers to adapt in the minds of participants. As the sector has shifted over the past 50 years towards larger, consolidated operations (Hart, 2003), these larger operations have gained an advantage in being able to produce commodities more competitively. Participants across all three counties consistently argued in favor of the quality of production they

offered over the bottom line production the larger growers are able to offer. However, participants saw the general public as seeking only the most bottom line product, while others saw growth and catered to a primarily well-heeled urban niche market. Such a position, several argued, was tenuous at best: when the United States economy contracts and disposable income decreases, niche foods, they claimed, were the first expenditures cut by households. Thus, the value the United States' consuming public places on "niche" foods as luxury and expendable in harder times translates into vulnerability for the smaller farmers that provide for such markets.

Adaptation to these threats and circumstances, in the minds of the participants of this research, differed depending on the scale of processes to which they were adapting. At the farm scale, adaptation largely depended on the individual: his or her personality being compatible with the daily challenges of farming and acquiring the skill sets needed to thrive in such a dynamic sector. At the community scale, adaptation depended on increasing connections and understanding between operators and the non-farming public. Such connections facilitated greater transmittal of knowledge and assistance thus providing a degree of stability in the community, even in times of disturbance. At the food system scale, participants saw adaptation as support in terms of suitable programs focused on smaller producers, especially in infrastructure, public education as to the realities of farming, and assisting in transitioning farms to the next generation. In sum, participants largely saw adaptation as a means of achieving some sort of stability in their operations.

5.2 Stability and Resilience in Western Washington

If there was one overarching concept that workshop participants were attracted to, it would be certainty and stability in their operations with participants viewing the lack of stability as a primary threat and seeking to enhance stability as an adaptive strategy. Many themes running through the workshop discussions, although not stated in such terms, had at their base the notion of stability. Participants saw market stability as facilitating better planning of resource use and marketing strategy. They saw climatic and weather stability as facilitating better planting and harvesting. Participants saw stability in government policy as facilitating easier compliance with existing regulations. They saw reliability of transportation systems and land ownership as facilitating a better business environment.

However, a vein of thought in the ecological resilience literature going back to the 1970s marks a difference between stability and resilience (Holling, 1973; King, 2008; Klein, Nicholls, & Thomalla, 2003; Nelson, Adger, & Brown, 2007). Whereas a stable system may quickly return to equilibrium after minor disturbance, perceived stable systems may collapse following major disturbance due to lacking "learned" ability to handle disturbance. A system displaying resilience may not return to normal as quickly; it will, however, have a greater ability to deal with major disturbance and persist.

Successful agriculture depends on managing uncertainty, the constant struggles with which create habits of adaptation. The sector makes or attracts individuals with a high capacity for adaptation due to the challenges farmers face on a daily basis. The farmers participating in the disaster-planning workshops in San Juan, Snohomish, and

Whatcom Counties displayed such adaptive, resilient attributes. Surviving (some thriving) through the changing cultural, economic, built, and rural landscapes of Puget Sound over the past 20 – 30 years, they have developed a skill set attuned to survival. This, however, does not mean farmers do not want regularity and predictability in their operations and lives.

The desire for predictability was manifest in dominant themes of the workshops: relevant threats at the farm, community, and food system scales, respectively, were lack of clear ownership succession, turnover of community members and land owners, and uncertainty in terms of regulation and the general public's mood. Each threat relates to a lack of stability in one or more facets of their relationship with the socio-ecological system around them. As the lack of stability in their seasonal and sometimes daily lives ensures the development of habits of adaptation, it can also seem like a constant assault, and thus a threat, to the long-term persistence of their operations. Thus, adaptive strategies that participants suggested had some component of bringing greater stability to some aspect of their operations: better and more stable access to information, more stable land ownership, and government support through education and infrastructure projects.

So, how can resilience, learned through feedback from minor disturbance that might not be desirable to farmers, be enhanced while fostering a stable, predictable business environment? This seems to be the paradox of socio-ecological resilience: akin to swallowing bitter medicine because it will benefit the patient in the long-term. According to the participants of this research, a starting point would be a shift in thinking at the policy level about what constitutes stability. Rather than focusing on

promoting stability in the sector through price stabilization, programs might focus on promoting stability in the sector's physical infrastructure and training. However, while this might level the playing field among the different sized producers, it is doubtful that any program will provide the level of stability desired. Agriculture is an inherently unstable sector, due to weather and market influences, and will remain unpredictable until methods are found to stabilize or somehow control these driving forces. Such stabilization will likely destroy the lifestyle that many of the study participants pursue.

5.3 Further Research and Concluding Remarks

Northwest Washington farmer perspectives on threat, vulnerability, and resilience indicate a sophisticated knowledge of their situation within larger socio-ecological systems. Farmers interact within several scales of these larger systems, navigating threats, avoiding thresholds, and employing strategies to ensure that their operations persist. Such strategies arise from experience and communication with other farmers in similar situations, though the processes that create this habit of adaptation may at times resemble a threat. Future research might build upon this thesis by isolating either a single scale or a single category and expanding upon the groundwork that I have laid here. Specifically, well-described thresholds need to be identified and methods to measure proximity to thresholds would benefit academic researchers as well as farmers and other policymakers committed to serving the agricultural sector. While threat and system identity will remain ambiguous and unique to specific situations, the adaptive strategies identified in this research should be

examined as to relative merit and effectiveness in forestalling potential transition to an undesirable system state or collapse of a community resource.

This thesis, through the perspectives of Northwest Washington Farmers, advances an argument that the United States' agricultural sector is a complex system operating at several scales, governed by economics and a public discourse that places value on certain aspects of the sector. Embedded within this socio-ecological system, farm operators encounter unique situations through combinations of physical and social processes occurring at several nested scales. In the context of these unique processes, they struggle to adapt their operations to the feedback they receive. To do so requires a specific personality, financial savvy, a supportive network, and the ability to situate oneself within the larger socio-ecological system such that the next disturbance will not result in the crossing of a threshold.

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Appendix A: Protecting Human Research Participants Certification

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Bryant Hammond** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 09/17/2008

Certification Number: 97078